

Date: Wednesday, 06/05/2009 8:52:04 AM
 User: Julie Dawson

Process Sheet

Customer : CU-DAR001 Dart Helicopters Services	Drawing Name : BEARPAW KIT (19"X24")
Job Number : 47764	
Estimate Number : 12615	
P.O. Number :	Part Number : D350578011
This Issue : 06/05/2009 S.O. No. :	Drawing Number : D2432 REV F3
Prsht Rev. : NC	Project Number : N/A
First Issue : / / Type : MACHINED PARTS	Drawing Revision : F3
Previous Run : 46220	Material :
Written By :	Due Date : 13/05/2009 Qty: 10 Um: Each
Checked & Approved By : <u>JUD 09-05-06</u>	
Comment : Est Rev:A New Issue 07-01-02 JLM	
Est Rev:B 08-01-09 Added Step 2 JLM Verified	
By:EC	
Est Rev:C 08-10-15 New Manufacturing Method JLM	
Verified By:EC	

Additional Product

Job Number:



Seq. #:	Machine Or Operation:	Description :
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1.0	DC	DOCUMENT CONTROL
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for JUD 09/05/20

**Comment:** DOCUMENT CONTROL

Photocopy bluefile and create labels per PPP D350-578-011 CHG005

8 09/05/21

2.0	MFG ENGINEERING	MFG ENGINEERING
-----	-----------------	-----------------

**Comment:** MFG ENGINEERING

Program Batch Number

J.F.S. 09/05/07

3.0	MUHMWB10	UHMW 1" Black
-----	----------	---------------

**Comment:** Qty.: 3.4088 sf(s)/Unit Total : 34.0883 sf(s)

Material: Black UHMW 1"

(MUHMWB10)

Batch: 111354

IB 9-5-8

(20)

4.0	WATER JET	FLOW WATER JET
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**Comment:** FLOW WATER JET

Cut Blank as per D2432 File


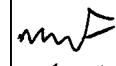

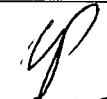

IB 9-5-8

NER

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: D350-578-011 PAR #: _____ Fault Category: _____ NCR: Yes ☒ No ☐ DQA: AD Date: 09/05/05

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR: <u>47764</u>		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			
09.05.13	5	Depth of cure is up to 0.050 too deep. R.C operator error.	 09.05.13 pu QSI 042	Acceptable pu attached SR	 09/05/	 09/05/15	 09.05.13 pu QSI 042	 09/05/15

NOTE: Date & initial all entries

Date: Wednesday, 06/05/2009 8:52:05 AM
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Customer: CU-DAR001 Dart Helicopters Services

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Job Number: 47764

Part Number: D350578011

Job Number:



Seq. #:	Machine Or Operation:	Description :
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5.0

HAAS1

HAAS CNC VERTICAL MACHINING #1



Comment: HAAS CNC VERTICAL MACHINING #1

Note:(2) bearpaws for (1) Kit

1-Inspect material for defects or damage prior to machining

2-Machine as per Folio and Dwg D2432 Identify as D2432F

3-Deburr

mmf 09/05/11 BB 09/05/12

6.0

QC2

INSPECT PARTS AS THEY COME OFF MACHINE



Comment: INSPECT PARTS AS THEY COME OFF MACHINE

mmf 09/05/11

(10)

7.0

QC8

SECOND CHECK



Comment: SECOND CHECK

mmf 09/05/14

(10)

8.0

PACKAGING 1

PACKAGING RESOURCE #1



Comment: PACKAGING RESOURCE #1

Pick Packing Kit

9.0

D2182B

Rubber Cushion



Comment: Qty.: 2.6250 f(s)/Unit Total: 26.2500 f(s)

Pick: Packing Kit

Qty Part Number Description Batch

6 D2182B050 Rubber Cushion

45405

X 9/5/19

SP

10.0

D2274

Radius Block



Comment: Qty.: 12.0000 Each(s)/Unit Total: 120.0000 Each(s)

Pick: Packing Kit

Qty Part Number Description Batch

12 D2274 Radius Block

2 D2432F(ref only) Bearpaw

44547

2 43838

(22) 347796

(10X)

9/5/19

SP

W/O:		WORK ORDER CHANGES					
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Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR:		WORK ORDER NON-CONFORMANCE (NCR)						
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Drawing Name: BEARPAW KIT (19"X24")

Job Number: 47764

Part Number: D350578011

Job Number:



Seq. #: Machine Or Operation: Description :

11.0

D2438

Clamp



Comment: Qty.: 6.0000 Each(s)/Unit Total : 60.0000 Each(s)

Pick: Packing Kit

Qty Part Number Description Batch

6 D2438

Clamp

1543840

46113

9/5/19

SP

12.0

D2529

Washer



Comment: Qty.: 12.0000 Each(s)/Unit Total : 120.0000 Each(s)

Pick: Packing Kit

Qty Part Number Description Batch

12 D2529

Washer

15388

9/5/19

SP

13.0

AN417A

Bolt



Comment: Qty.: 12.0000 Each(s)/Unit Total : 120.0000 Each(s)

Pick: Packing Kit

Qty Part Number Description Batch

12 AN4-17A

Bolt

1107321

9/5/19

SP

14.0

AN960JD416

Washer



Comment: Qty.: 24.0000 Each(s)/Unit Total : 240.0000 Each(s)

Pick: Packing Kit

Qty Part Number Description Batch

24 AN960JD416

Washer

1110363

235
1111279

9/5/19

SP

15.0

MS21042L4

Nut



Comment: Qty.: 12.0000 Each(s)/Unit Total : 120.0000 Each(s)

Pick: Packing Kit

Qty Part Number Description Batch

12 MS21042L4

Nut (or -4)

1110450

9/5/19

SP

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

NCR:		WORK ORDER NON-CONFORMANCE (NCR)						
DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

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Part Number: D350578011

Job Number:



Seq. #:

Machine Or Operation:

Description :

16.0

QC4

INSPECT 100% KITS FOR COMPLETENESS



Comment: INSPECT 100% KITS FOR COMPLETENESS

8/05/21

17.0

PACKAGING 1

PACKAGING RESOURCE #1



Comment: PACKAGING RESOURCE #1

Identify and pack for shipping as per PPP D350-578-011

Location: 11

for A 9/5/20

102

SO

18.0

QC21

FINAL INSPECTION/W/O RELEASE



Comment: FINAL INSPECTION/W/O RELEASE

09/05/21

Job Completion



MF
09-05-21

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

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			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

DART AEROSPACE LTD		Work Order: 47764
Description: Bearpaw		Part Number: D2432
Inspection Dwg: D2432	Rev: F3	Page 1 of 1

FIRST ARTICLE INSPECTION CHECKLIST

☒ First Article ☐ Prototype

Inspection Sheet	Drawing Dimension	Tolerance	Actual Dimension	Accept	Reject	Method of Inspection	Comments
A	0.063 x 45°	+0.030/-0.010	0.063 x 45°	✓			
B	5.500	+/-0.030	5.507	✓			
C	0.200	+/-0.030	0.212	✓			
D	0.25 x 45°	+/-0.030	0.25 x 45°	✓			
E	R0.250	+/-0.030	R0.250	✓			
F	0.250	+/-0.010	0.247	✓			
G	0.625	+/-0.030	0.607	✓			
H	0.375	+/-0.010	0.374	✓			
I	0.950	+0.030/0.010	0.947	✓			
J	19.000	+/-0.030	19.00	✓			
K	3.14	+/-0.030	3.14	✓			
L	3.28	+/-0.030	3.28	✓			
M	Ø0.260	+0.005/-0.000	0.260	✓			
N	Ø0.93	+/-0.030	0.92	✓			
O	0.30	+0.030/-0.000	0.340	✗	✓		
P	23.750	+/-0.030	23.750	✓			
Q	7.375	+/-0.030	7.375	✓			
R	4.250	+/-0.010	4.250	✓			
S	2.000	+/-0.030	2.00	✓			
T	9.000	+/-0.010	9.00	✓			
U	9.000	+/-0.010	9.00	✓			
V	0.375	+/-0.010	0.378	✓			
					accept		

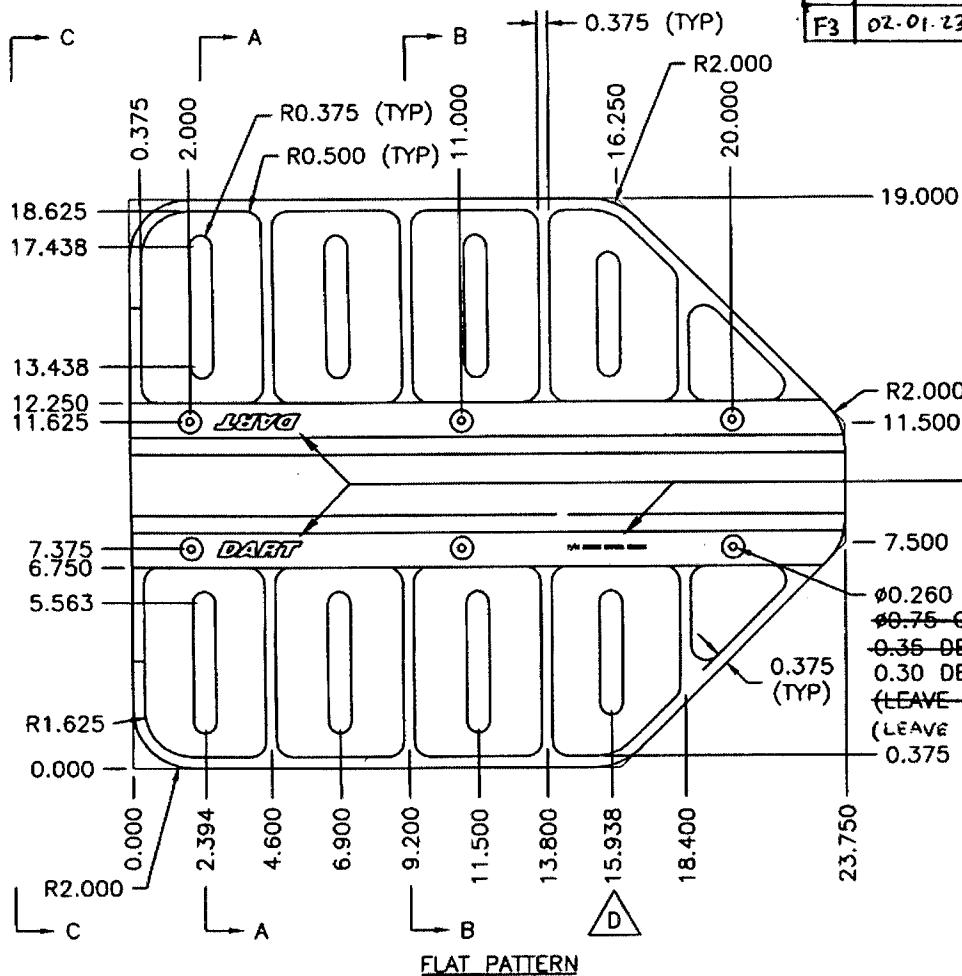
Measured by: <i>mmf</i>	Audited by: <i>mmf</i>	Prototype Approval:	N/A
Date: 09/05/11	Date: 09/05/14	Date:	

Rev	Date	Change	Revised by	Approved
A	04.01.09	New Issue P/O K10008/D206-559-015	KJ/RF	

DECLASSIFIED

93-06-17 K8

F1	99.03.03	ADD DEO 9143
F2	01.03.28	0.93 WAS 0.75 RF
F3	02.01.23	CLASSIFY CORE DMS RF



ENGRAVE LOGO TO MAX
DEPTH OF 0.012. ENGRAVE
PART AND BATCH NUMBERS
TO MAX DEPTH OF 0.010.
(TYPICAL LOCATION AS
ILLUSTRATED)

DESIGN		DRAWING BY		REV. F	
KE		KE		HAWKESBURY, ONTARIO, CANADA	
CHECKED		APPROVED		DRAWING NO.	
MM		JL		D2432	
DATE		TITLE		SHEET 1 OF 2	
98.05.12		BEARPAW		SCALE	
				1:6	
A	95.10.31	NEW ISSUE			
B	96.01.24	RE-DESIGN			
C	96.03.26	CHANGE BORE AND C'BORE DEPTH			
D	96.06.04	MOVE SLOT			
E	97.02.27	CHANGE C'BORE DEPTH, BORE RADIUS			
F	98.05.12	CHANGE C'BORE, ADD B AND F P/N			

EFFECTIVE	DEOS

9143

- 0.950 (REF)

D2432F: FLAT BEARPAW
D2432B: BENT BEARPAW

MATERIAL: UHMW BLACK PER SPEC CONTROL DRAWING D2689
1.00 THICK (MACHINE TO 0.950)

Copyright 1995 by DART AEROSPACE LTD

WITHOUT NOTICE
WORK ORDER
NO. 47764

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

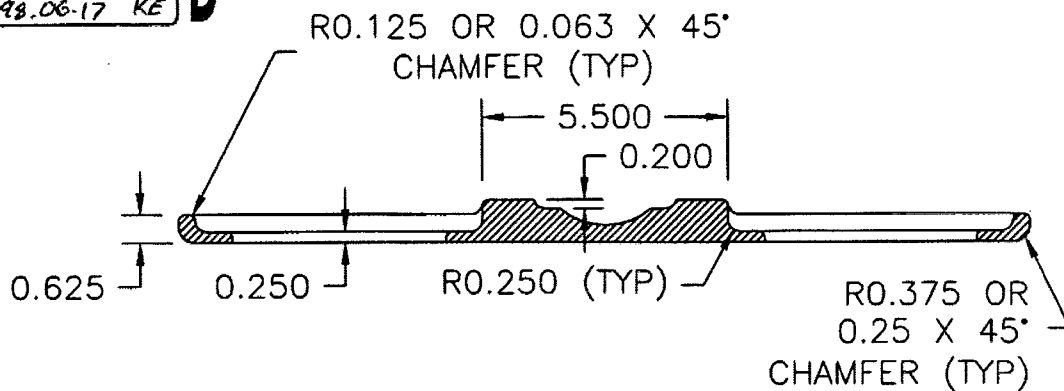
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DATE	STEP	Description of NC Section A	Corrective Action Section B			Verification Section C	Approval Chief Eng	Approval QC Inspector
			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

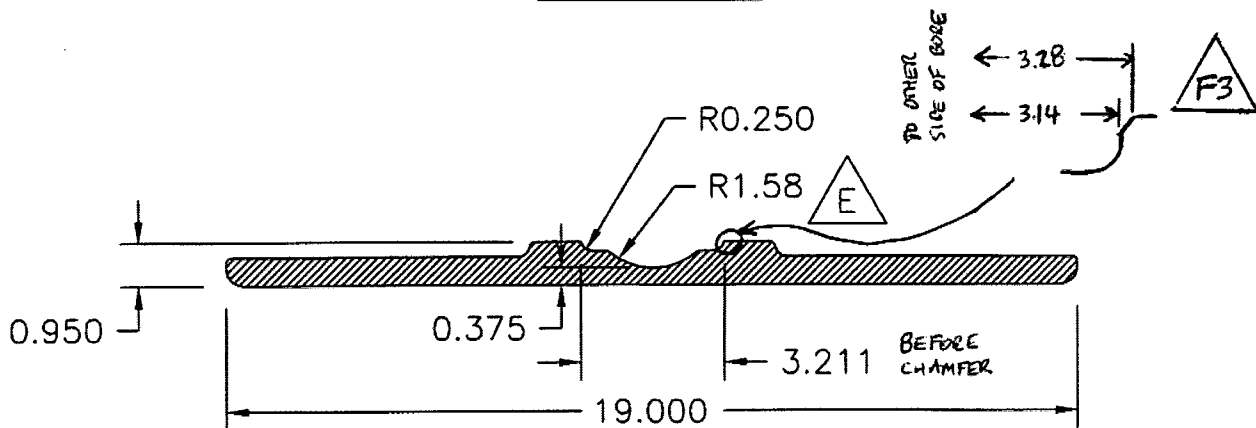


DESIGN KE	DRAWN BY KE	DART AEROSPACE LTD HAWKESBURY, ONTARIO, CANADA	
CHECKED [Signature]	APPROVED [Signature]	DRAWING NO. D2432	REV. F SHEET 2 OF 2
DATE 98.05.12	TITLE BEARPAW	SCALE 1:4	

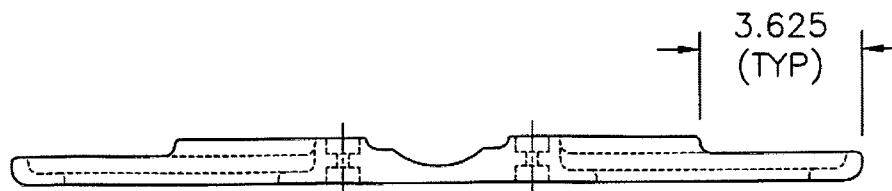
RELEASED
98.06.17 KE



SECTION A-A



SECTION B-B



SECTION C-C

SHOP COPY
RETURN TO
ENGINEERING
UNCONTROLLED COPY
SUBJECT TO AMENDMENT
WITHOUT NOTICE
WORK ORDER
NO. 47764

W/O:		WORK ORDER CHANGES					
DATE	STEP	PROCEDURE CHANGE	By	Date	Qty	Approval Chief Eng / Prod Mgr	Approval QC Inspector

Part No: _____ PAR #: _____ Fault Category: _____ NCR: Yes No DQA: _____ Date: _____

Resolution: _____ Disposition: _____ QA: N/C Closed: _____ Date: _____

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			Initial Chief Eng	Action Description Chief Eng	Sign & Date			

NOTE: Date & initial all entries

$$GW := 3860 \cdot \text{lbf}$$

Aircraft Gross Weight for Condition #2
(1g static load per Memorandum in
Appendix A of ACP-D315-670)

$$A1 := 226.76 \cdot \text{in}^2$$

Area Fwd C of G (based on area of skidtube in
contact with ground forward of critical C of G at
STA 124.0)

$$A2 := 434.95 \cdot \text{in}^2$$

Area Aft C of G (based on area of skidtube and
bearpaw in contact with ground aft of critical C of
G at STA 124.0)

$$\begin{aligned} Ab &:= 392.94 \cdot \text{in}^2 \\ d1 &:= 35.99 \\ d2 &:= 23.16 \end{aligned}$$

Area of Bearpaw
Distance to C of A1 (See Figure 1)
Distance to C of A2 (See Figure 1)

$$F2 := \frac{0.5 \cdot GW}{\left(\frac{d2}{d1}\right) + 1} \quad F2 = 1174.31 \cdot \text{lbf}$$

Load Applied at Center Area (A2) derived from
summation of moments about the point of
loading of F1

$$F1 := 0.5 \cdot GW - F2 \quad F1 = 755.69 \cdot \text{lbf}$$

Load Applied at Center Area (A1)

$$P1z := \left(\frac{Ab}{A2}\right) \cdot F2 \quad P1z = 1060.9 \cdot \text{lbf}$$

Ground Load Per Bearpaw (upwards) assuming
that the skidtube takes a fractional share of the
load based upon areas.

$$P1x := 0.5 \cdot P1z \quad P1x = 530.4 \cdot \text{lbf}$$

Drag Load per Bearpaw (aft) assuming a friction
co-efficient of 0.50 between the ground and the
bearpaw.

$$P1y := 0.5 \cdot P1z \quad P1y = 530.4 \cdot \text{lbf}$$

Drag Load per Bearpaw (sideways) assuming a
friction co-efficient of 0.50 between the ground
and the bearpaw.

b) Air Loads (ref. CAR 6.211 - Flight Load Factors)

The dynamic pressure, q, on the bearpaw must be calculated using the aircraft Vne and a force co-efficient of Cn = 0.55.

$$Cn := 0.55$$

Force Co-efficient (refer to Memorandum in
Appendix A of ACP-D315-670)

$$\rho := 0.00238 \cdot \text{slug} \cdot \text{ft}^{-3}$$

Air Density

$$V := 190.7 \cdot \text{ft} \cdot \text{sec}^{-1}$$

Based on Vne = 113 KIAS (refer to Memorandum
in Appendix A of ACP-D315-670)

$$q := 0.5 \cdot \rho \cdot Cn \cdot V^2$$

$$V = 292 \text{ ft/s FOR 173 KIAS}$$

$$q = 0.39 \text{ lbf/in}^2$$

$$q = 0.17 \text{ lbf/in}^2$$

Bearpaw Pressure

$$Ab := 392.94 \cdot \text{in}^2$$

Bearpaw Vertical Area

$$P2z := q \cdot Ab$$

$$P2z = 152.28 \text{ lbf} = P_{\text{down}}$$

$$P2z = 64.95 \cdot \text{lbf}$$

Air Load (upward/downward)

$$Ah := 19 \cdot \text{in}^2$$

Bearpaw Horizontal Area

$$P2x := q \cdot Ah$$

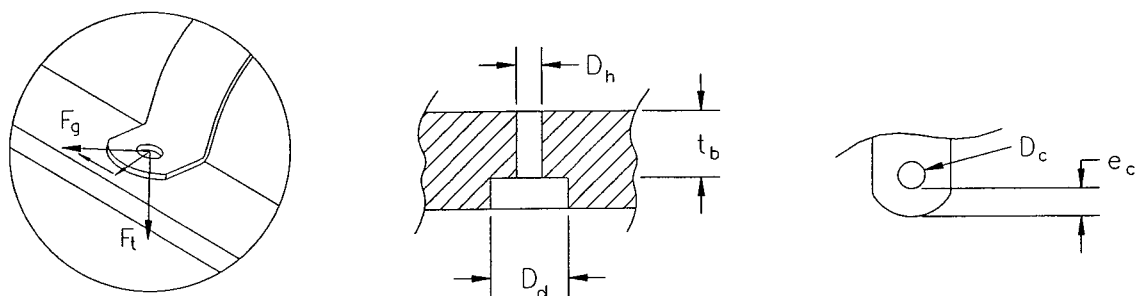
$$P2x = 3.14 \cdot \text{lbf}$$

Air Load (forward)

6.0 Clamping Analysis

The largest loads in the clamps come from tightening down the bolts that attach the clamps to the bearpaw. The upward ground loads analyzed in section 4 unload the clamps while the downward ground loads analyzed in section 5 load the clamps. Therefore, the highest load in the clamps is the summation of the tensile load in the attachment bolts added to the tensile load transferred to the clamps from downward air loads. Additionally, the clamps must be able to withstand the ground drag loads introduced into the bearpaw installation by P_{fwd} and P_{side} . Figure 3 below diagrams the loads involved in this analysis.

Figure 3



6.1 Clamp Load Calculation

Tensile Load from the Bolts

$$T := 13 \cdot \text{in} \cdot \text{lbf}$$

$$D1 := 0.315 \cdot \text{in}$$

$$Tr := 20 \cdot \text{in} \cdot \text{lbf} - T$$

$$F := \frac{2 \cdot Tr}{D1}$$

$$tpi := 28 \cdot \text{in}^{-1}$$

$$h := 0.219 \cdot \text{in}$$

$$Fb := F \cdot tpi \cdot h$$

$$Tr = 7 \cdot \text{in} \cdot \text{lbf}$$

$$F = 44.4 \cdot \text{lbf}$$

$$Fb = 272.5 \cdot \text{lbf}$$

Torque required to thread nut on to bolt
(determined from tests - see excerpt from approved
Dart Bearpaw report SR206-559, Appendix C)

Distance across flat faces of MS21042-4 nut

Resultant Torque after tightening to 20 in.lb (max.
specified torque outlined in IIN-D315-670)

Tangential force applied to nut

Threads per inch of bolt and nut (UNF)

Height of thread in nut (to calculate percentage
of screw under axial load induced by nut)

Load per fastener

Tensile Load Transferred from Pdown

$$n := 6$$

$$Fa := \frac{P_{down}}{n}$$

$$Fa = 10.82 \cdot \text{lbf}$$

$$Fa = 25.38 \cdot \text{lbf}$$

Number of fasteners (assume air loads are evenly
distributed between all 6 fasteners)

Load per fastener

Total Tensile Clamp Loads

$$F_t := (F_b + F_a) \cdot FF$$

$$F_t = 325.85 \cdot \text{lbf}$$

$$F_t = 342.6 \text{ lbf}$$

Total Tensile Clamp Load

Shear Loads Transferred from P_{fwd} and P_{side}

$$n = 6$$

Number of fasteners

$$F_g := \left[\sqrt{\left(\frac{P_{aft}}{n} \right)^2 + \left(\frac{P_{side}}{n} \right)^2} \right] \cdot FF \quad F_g = 143.77 \cdot \text{lbf}$$

Shear Load per fastener

6.2 Tensile Failure of the Clamp

$$w_c := 0.75 \cdot \text{in}$$

Clamp Width

$$t_c := 0.063 \cdot \text{in}$$

Clamp Thickness

$$A_c := w_c \cdot t_c$$

$$A_c = 0.05 \cdot \text{in}^2$$

Clamp Area

$$f_{ty} := \frac{F_t}{A_c}$$

$$f_{ty} = 6896.35 \cdot \text{psi}$$

Tensile Stress

$$MS_{4a} := \frac{F_{ty}^2}{f_{ty}} - 1$$

$$MS_{4a} = 2.92$$

Margin of Safety (Limit)

$$MS_{4b} := \frac{F_{tu}^2}{SF \cdot f_{ty}} - 1$$

$$MS_{4b} = 6.25$$

Margin of Safety (Ultimate)

6.3 Bearing Failure of the Clamp

$$D_c := 0.257 \cdot \text{in}$$

Clamp hole diameter

$$t_c := 0.063 \cdot \text{in}$$

Clamp thickness

$$A := D_c \cdot t_c$$

$$A = 0.02 \cdot \text{in}^2$$

Bearing Area

$$f_{by} := \frac{F_g}{A}$$

$$f_{by} = 8879.56 \cdot \text{psi}$$

Bearing Stress

$$MS_{5a} := \frac{F_{by}^2}{f_{by}} - 1$$

$$MS_{5a} = 4.63$$

Margin of Safety (Limit)

$$MS_{5b} := \frac{F_{bru}^2}{SF \cdot f_{by}} - 1$$

$$MS_{5b} = 10.26$$

Margin of Safety (Ultimate)

Note: MIL-HDBK-5C does not provide values for F_{bru} and F_{by} for e/D of 1.5 in the annealed condition. It is recognized that the configuration of the part has an e/D of 1.56, but because the bearing margins of safety for the strap are excessively high, it is believed that the above analysis adequately demonstrates the structural integrity of the strap for this installation, and demonstrates compliance to the applicable regulations.

6.4 Shear Failure of the Clamp

$$ec := 0.272 \cdot \text{in}$$

$$tc := 0.063 \cdot \text{in}$$

$$A := 2 \cdot ec \cdot tc$$

$$A = 0.03 \cdot \text{in}^2$$

$$fsy := \frac{F_g}{A}$$

$$fsy = 4194.94 \cdot \text{psi}$$

$$MS6a := \frac{F_{sy2}}{fsy} - 1$$

$$MS6a = 3.29$$

$$MS6b := \frac{F_{su2}}{SF \cdot fsy} - 1$$

$$MS6b = 6.95$$

Clamp edge distance

Clamp thickness

Shear Area

Shear Stress

Margin of Safety (Limit)

Margin of Safety (Ultimate)

6.5 Pull-out Failure of the Bearpaw

$$Db := 0.75 \cdot \text{in}$$

$$tb := 0.650 \cdot \text{in} \quad t_b = 0.600 \cdot \text{in}$$

$$A := \pi \cdot Db \cdot tb$$

$$A = 1.53 \cdot \text{in}^2$$

$$fsy := \frac{F_t}{A}$$

$$fsy = 242.34 \cdot \text{psi}$$

$$fsy = 212.76 \cdot \text{psi}$$

$$MS7a := \frac{F_{sy1}}{fsy} - 1$$

$$MS7a = 9.37 = 8.10$$

$$MS7b := \frac{F_{su1}}{SF \cdot fsy} - 1$$

$$MS7b = 9.97 = 8.63$$

Counterbore hole diameter

Bearpaw thickness

Shear Area

Shear Stress

Margin of Safety (Limit)

Margin of Safety (Ultimate)

MARGINS still
positive & OKCP
09.09.13**6.6 Bearing Failure of the Bearpaw**

Note that the bearing properties of the material (F_{bry1} and F_{bru1}) were determined from testing outlined in Dart Report DR-1041, in Appendix B.

$$Dh := 0.257 \cdot \text{in}$$

$$tb := 0.650 \cdot \text{in}$$

$$A := Dh \cdot tb$$

$$A = 0.17 \cdot \text{in}^2$$

$$fby := \frac{F_g}{A}$$

$$fby = 860.63 \cdot \text{psi}$$

$$MS8a := \frac{F_{bry1}}{fby} - 1$$

$$MS8a = 2.25$$

$$MS8b := \frac{F_{bru1}}{SF \cdot fby} - 1$$

$$MS8b = 2.25$$

Bearpaw hole diameter

Bearpaw thickness

Bearing Area

Bearing Stress

Margin of Safety (Limit)

Margin of Safety (Ultimate)